

Outcome of Non-Invasive Ventilation in Patients of Acute Respiratory Failure

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ABSTRACT

Introduction: Non-invasive ventilation (NIV) is a method of ventilator support or delivery of positive pressure into the lungs usually through a face mask, mostly initiated before severe acidosis occurs. NIV failure requiring invasive mechanical ventilation in decompensated chronic obstructive pulmonary disease (COPD) patients is low, but, in critical patients, it is as high as 60%. Acute respiratory failure (ARF) is the common reason for admission to the intensive care unit. This study assesses the outcome of NIV among patients with acute respiratory failure, the duration of use, stay in ICU, and failure rate of NIV. Such type of study result is scarce in our country.

Methods: Arterial blood gases were assessed prior, after, and at discontinuation of NIV. NIV was delivered by ventilator via face mask. All patients above age 15 years who presented to the hospital, diagnosed to have ARF by ABG were included and admitted to Medical Intensive Care Unit (MICU). Appropriate statistical tests (Chi-square) were performed and the statistical significance of the results was assessed.

Results: 35 patients with the median age of 73 years (range: 39- 89 years), of 60.0 % females among which 74.3 % were current smokers. Arterial blood pH prior to admission ranged from 7.11-7.39 and 7.06-7.41 among NIV success and failure, respectively. Similarly, P_{CO2} ranged from 54.0-127.5 and 29.5-105.9 among them, respectively. Two hours after ventilation pH ranged from 7.12-7.43 and 7.05-7.30 respectively in the success and failure group. The most common disease condition requiring NIV was 77.1% COPD. Out of NIV failure group (n=19) ,57.8 % were intubated and 42.1% patients left the intervention.

Conclusions: Usage of NIV among ARF patients was associated with lower intubation and ICU mortality rate. COPD patients showed the most benefit with NIV, whereas patients suffering from interstitial lung disease, lung cancer had less benefit.

INTRODUCTION

Acute Respiratory failure (ARF) is a condition in which the respiratory system fails in one or both of its gas exchange functions, i.e. oxygenation and/or elimination of carbon dioxide from mixed venous blood. Hypoxemic respiratory failure (type I) is characterized by an arterial oxygen tension (PaO₂) <8kpa (60 mmHg) with a normal or low arterial

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carbon dioxide tension (PaCO_2).¹Hypercapnic respiratory failure (type II) is characterized by a $\text{PaCO}_2 > 6.0 \text{ kPa}$ (45 mmHg). Common etiologies include drug overdose, neuromuscular disease, chest wall abnormalities, and severe airway disorders like COPD.²

Noninvasive ventilation (NIV) refers to the delivery of ventilator support or positive pressure into the lungs without an invasive endotracheal airway usually through a mask. To ensure better outcomes in terms of preventing intubation and mortality, NIV should be initiated early, before severe acidosis occurs. The rate of NIV failure requiring invasive mechanical ventilation (IMV) in decompensated COPD patients is low, but in critical patients it may be as high as 60% (5% to 60%).³NIV appears to be of benefit in the immediate treatment of patients with acute cardiogenic pulmonary edema and may reduce mortality. NIV produces greater improvements in oxygenation and carbon dioxide clearance and a greater reduction in the work of breathing in patients with pulmonary edema.⁴

Pandey R et al study revealed that out of 28 patients, 27 received bi-level and most common cause was chronic obstructive pulmonary disease with type 2 respiratory failures in 67.8%.⁵

Rationale of this study was to see the effectiveness of NIV in ARF patients despite any cause, stay of ICU duration and its outcomes and failure rate of NIV.

METHODS

A single-center, cross-sectional, observational study at medical ICU of a tertiary level hospital in Nepal was conducted. All patients above age 18 years presented to the hospital diagnosed to have acute respiratory failure by arterial blood gas analysis with $\text{pH} < 7.3$ were admitted in MICU. Patient's identification and details regarding admission requirement to be kept in Non-invasive ventilation were filled in the proforma. All the details of clinical parameters during the admission and ABG findings during admission were recorded before putting the patient in NIPPV.

During NIV via Mechanical Ventilator parameters like PEEP, Pressure Support (PS) or Inspiratory positive airway pressure (IPAP) with required fraction of inspired oxygen (FiO_2) were set and recorded. Any changes in the parameters during

the NIV application were also be recorded as per the proforma.

NIV was delivered through a face mask by a ventilator with oxygen of maximum FiO_2 60% in order to maintain peripheral oxygen saturation above 88%. NIV was started at an inspiratory positive airway pressure of 8 cm of water and an expiratory positive airway pressure of 4 cm of water and increased to a maximum inspiratory pressure of 20 cm of water and a maximum expiratory pressure of 10 cm of water. Depending on the severity of the illness, informed written or witnessed oral consent from the patient or witnessed consent from a relative were obtained at entry into the study. Data will be tabulated and interim analysis be performed in Microsoft Excel. Results will be presented in tables, graphs and diagrams. Appropriate statistical tests will be performed and the statistical significance of the results will be assessed.

Exclusion criteria for NIV:

Need of Intubation (Lifesaving or emergency intervention).

Need of high dose vassopressor Support

Facial Injury.

Unconscious Patients

RESULTS

Total 35 patients were enrolled in this study, had the median age being 73 years (Range: 39 – 89 years) out of which 40.0 % were males and 74.3 % were current smokers. Majority of the patients (91.4 %) presented with shortness of breath and cough (40.0 %), fever (14.3 %). Table 1 describes the patients according to diagnosis who received NIV.

TABLE 1. Classification of patients based on working diagnosis.

S. No.	Working diagnosis	n (%)
1.	COPD/BA	27 (77.1)
2.	ILD	4 (11.4)
3.	Pneumonia	2 (5.7)
4.	Pulmonary edema	1 (2.9)
5.	Ca Lung	1 (2.9)

NIV success was more in COPD (40%) patients as shown in Table 2. Median duration of NIV was 17

h (6 – 56 h) among the success group.

TABLE 2. Overall days of ventilator support among NIV success group

Crosstab ^a				
		Working diagnosis		Total
		COPD/BA	ILD	
Total Days	1	3	1	4
	2	7	0	7
	3	1	1	2
	4	3	0	3
Total		14	2	16

a. NIV failure = No

NIV failure was observed in 54.3 % and it was not significantly associated with working diagnosis (Chi-square = 3.81, P = 0.43) as shown in Table 3 and 4. Failure rate of NIV was 100 % in patients of pneumonia, pulmonary edema and carcinoma lung (n =4). Whereas failure rate for COPD was 48.1 % and ILD 50.0 %. The median duration of NIV was 10 h (2 – 57 h) among failure group.

TABLE 3. Overall days of ventilator support among NIV failure group

Crosstab ^a							
Count		Working diagnosis					Total
		COPD/BA	Pulmonary edema	Pneumonia	Ca Lung	ILD	
Total Days	1	10	1	1	0	2	14
	2	1	0	1	1	0	3
	3	1	0	0	0	0	1
	4	1	0	0	0	0	1
Total		13	1	2	1	2	19

a. NIV failure = Yes

TABLE 4. Outcome of NIV failure:

Crosstab ^a							
Count		Working diagnosis					Total
		COPD/BA	Pulmonary edema	Pneumonia	Ca Lung	ILD	
Outcome	INTUBATED	9	0	0	0	2	11
	LAMA	4	1	2	1	0	8
	4	1	0	0	0	0	1
Total		13	1	2	1	2	19

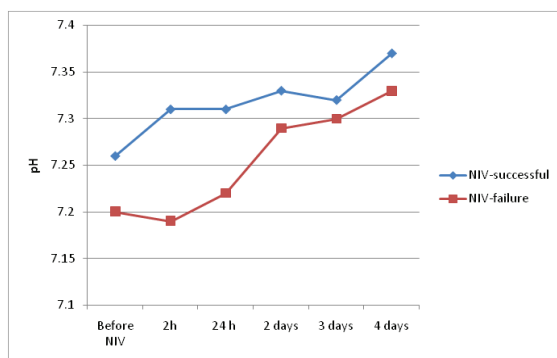
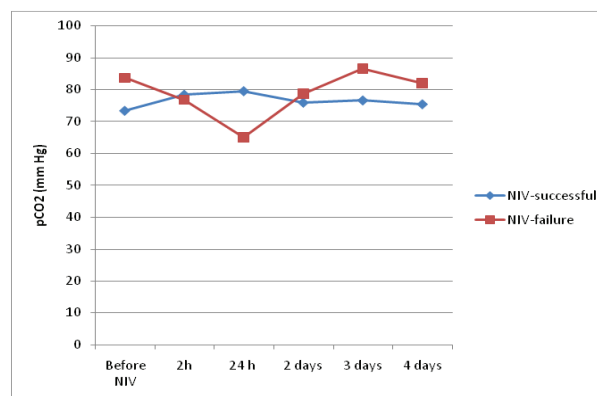
a. NIV failure

Table 4 depicts the ABG analysis and ventilator parameters among both success and failure group of NIV patients.

TABLE 5. ABG analysis parameters and ventilator parameters in patients of COPD/BA (n = 27) tabulated according to NIV success and failure

	NIV success group						NIV failure					
	Before NIV	2 h after NIV	Day 1	Day 2	Day 3	Day 4	Before NIV	2 h after NIV	Day 1	Day 2	Day 3	Day 4
pH	7.26 (7.11-7.39)	7.31 (7.12-7.43)	7.31 (7.16-7.38)	7.33 (7.17-7.46)	7.32 (7.27-7.37)	7.37 (7.37-7.41)	7.20 (7.06-7.41)	7.19 (7.05-7.30)	7.22 (7.08-7.31)	7.29 (7.28-7.35)	7.30 (7.30-7.31)	7.33
pCO ₂	73.35 (54.0-127.5)	78.4 (33.6-134.4)	79.5 (55.0-139.0)	75.9 (47.5-116.8)	76.6 (68.0-89.0)	75.4 (64.5-82.4)	83.6 (29.5-105.9)	76.75 (45.6-122.0)	65.0 (48-126)	78.7 (54.9-82.0)	86.5 (84.2-88.9)	81.9
PaO ₂	80.5 (40.0-131.0)	69.0 (55.0-163.0)	79.5 (55.0-139.0)	67.0 (49-139)	73.5 (49.0-88.0)	71.0 (52.0-75.0)	86.0 (59.0-172.0)	68.5 (40.0-179.0)	65 (48-126)	61 (51-68)	60 (59-61)	65
HCO ₃	31.45 (22.80-51.1)	30.4 (22.1-53.3)	32.55 (22.20-55.30)	36.5 (27.2-53.7)	40.25 (31.7-47.3)	42.4 (35.7-51.7)	29.3 (17.8-37.7)	29.75 (21.9-43.0)	29.1 (22.8-35.6)	36.2 (25.4-43.8)	41.8 (40.6-43)	42.1
FiO ₂	30(21-80)	40(28-60)	31(21-60)	30 (21-40)	37 (30-40)		25 (21-60)	35 (30-60)	35 (30-80)	40 (29-88)	31 (30-33)	
Ven-tilator parameters												
Mode		CPAP:7 VC-SIMV:2	CPAP:13 VC-SIMV:1	CPAP:8 VC-SIMV:2 SIMV:1	CPAP:3 VC-SIMV:1			CPAP:8 VC-SIMV:2	CPAP:2 VC-SIMV:7	CPAP:2 VC-SIMV:1	CPAP:1 VC-SIMV:1	CPAP:1
Pressure support		10 (5-16)	10 (5-15)	10 (5-14)	14 (14-16)	14 (14-18)		10 (7-18)	14 (10-20)	18 (8-20)	20	16
Duration (hours)		2	6 (3-20)	10 (2-22)	13 (12-16)	11 (6-14)		2	10 (6-20)	17 (6-18)	16 (14-17)	5

Fig 1 and 2 shows the graphical representation of pH and PCO₂ among NIV success and failure group. ABG analysis reveals that during admission pH \leq 7.26 (range 7.11-7.39) Vs pH \leq 7.2 (range 7.06-7.41), pCO₂ \geq 73.35 (54-127.5) Vs pCO₂ \geq 83.6 (29.5-105.9) among NIV success group and failure group respectively.

FIGURE 1. Trend of pH among NIV successful and failure group.**FIGURE 2.** Trend of PCO₂ among NIV successful and failure group.

DISCUSSION:

35 patients were admitted in MICU for ARF in CMCTH, among which 40% were males and age ranged from 39–89 years with median age being 73 years. The efficacy of NIV depends on several factors like the experience of medical team, adequate patient selection, and adequate selection of interface, appropriate ventilator settings and implementation of protocols.⁶

Nikolina Marić et al study done over 1 year revealed mean age of 69.8 years (ranging from 32 to 92 years), 58.3% male and 41.7% female. 688 patients were hospitalized in ICU, and 108 (15.7%) were treated by NIV and 29% patients were intubated. ⁶ Pandey R et al study revealed that thirty-four patients received NIV out of which 6 were excluded from the study due to insufficient documentation. 27 received bi-level and one patient received Continuous Positive Airway Pressure. Mean age of patients was 66.5 years and ranged from 42–87 years.⁵

Carlucci, Richard, Wysocki, et al prospective survey done in 42 ICU of European country over 1 month period, 689 patients required invasive or noninvasive mechanical ventilation. 35% patients required NIV without intubation and the distributions was as follows: 48% of patients had hypoxemic ARF, including pneumonia (10%) and postoperative failure (15%); 15% hypercapnic ARF; 30% had coma; and 7% had cardiogenic pulmonary edema. The mean length of NIV according to the reason for mechanical ventilation was 6.3 ± 6.8 d (range: 1–29 d) in hypoxemic ARF, 5.6 ± 5.4 d (range: 1–24 d) in hypercapnic ARF, and 2.4 ± 2 d (range: 1–6 d) in pulmonary edema.⁷ According to our study most patients had hypercapnic ARF, distribution includes 77.1% COPD, 11.4% ILD, 5.7% Pneumonia and 2.9% lung cancer.

T. Köhnlein et al study done at large multicenter in the emergency room included 130 patients with ARF who were randomized to receive Usual Medical Care (UMC) and NIV. 24.6% patients allocated NIV had to be intubated and 75% patients were treated successfully without the need for intubation.⁸ Whereas in our study NIV failure was observed in 54.3% overall, failure rate for COPD was 48.1% and ILD 50.0%.

In Pandey R et al study Arterial blood pH prior to admission ranged from 7.19 to 7.50. Twelve hours after bi-level ventilation, only 21.3% had pH < 7.35

and 42.8% had pCO₂ above 60 mm Hg. NIV was successful in 27 patients (96.4%).⁵ Whereas in our study ABG during admission pH ≤ 7.26 (range 7.11–7.39) Vs pH ≤ 7.2 (range 7.06–7.41), pCO₂ ≥ 73.35 (54–127.5) Vs pCO₂ ≥ 83.6 (29.5–105.9) among NIV success group and failure group respectively.

Limitations of our study are the relatively small sample size and this was an observational study. Failure of NIV could potentially represent a risk factor for complications.

CONCLUSIONS

Usage of NIV among ARF patients was associated with lower intubation and ICU mortality rate. COPD patients showed most benefit with NIV. Whereas patients suffering from Interstitial Lung disease, Lung Cancer had less benefit, with NIV failure of 57.8%. The median duration of NIV use among success group was 17 h and failure group 10h.

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